EPSC Abstracts
Vol. 8, EPSC2013-654, 2013
European Planetary Science Congress 2013

A new CRISM data analysis tool for the detection of miscellaneous alteration phases

B. Bultel(1), C. Quantin(1), M. Andreani(1), H. Clenet(1,2)
(1) Laboratoire de Géologie de Lyon (Laboratoire de Géologie de Lyon, Bâtiment Géode 2 Rue Raphael DUBOIS 69622 VILLEURBANNE CEDEX. (2) École Polytechnique Fédérale de Lausanne. benjamin.bultel@univ-lyon1.fr, cathy.quantin-nataf@univ-lyon1.fr.

Abstract

The high spatial resolution of CRISM targeted mode data has revealed the mineral diversity of Mars, especially in terms of alteration minerals. However, even in targeted mode the signal to noise ratio (SNR) is not high enough to discriminate minerals spectrally close such as dolomite, serpentine and chlorite. Here, we report the development of a CRISM noise removal pipeline as well as a tool of analysis to highlight minerals with absorption combinations in the 2.3-2.5 µm domain.

1. Introduction

CRISM (Compact Reconnaissance Imaging Spectrometer for Mars) onboard MRO (Mars Reconnaissance Orbiter) is a spectro-imager between 0.4-4.0 µm (visible to near infrared, [1]). The NIR is often used to detect the hydrated mineral on the surface as they have characteristic absorption near 1.9 µm and between 2.1 and 2.6 µm [1].

The data require a pre-processing phase before to be studied. CAT (CRISM Analysis Toolkit) is a pipeline used to correct the photometric angles and the atmosphere contribution. It is also used to correct the data from the noise [1, 2, 3, 4]. However, the CAT processing does not provide a signal enough cleaned from noise. It is challenging to differentiate clearly two different mineral with slight spectral difference (example of dolomite, serpentine and chlorite, [5, 6, 7]). We develop a new pipeline of processing as a complement of CAT to remove the noise and ratioing the hyperspectral cube. A tool of analysis is also developed as complement to the spectral criteria to highlight the presence of chlorite, serpentine and carbonates on a cube. We present here these methods and their tests on artificial data cube built with artificially noised spectra from library.

2. Methods

2.1 Noise removal pipeline:

We design a noise removal pipeline to be used after CAT preprocessing to smooth and denoise the data. First, the pipeline applies sharpening-median filter then a mobile median filter and end with a mobile average filter. The first filter detects absurd values and replaces them, the others filters smooth the spectrum (Fig.1). Once the data cube cleaned, we process a ratio of the totality of the cube with an average spectrum of the cube to remove the contribution of the dust.

2.2 Plot of combinations of absorptions:

The discrimination between phyllosilicates and carbonates is investigated by the analysis the combinations of absorptions in the 2.3-2.5 µm domain [7, 8]. We develop a tool running under IDL language to count the number of pixel for each possible combination of absorption centered near 2.3 µm and 2.5 µm. We choose to represent the number of combinations counted by a color scale in a graphic with center of absorption near 2.3µm in abscissa and the center of absorption near 2.5µm on vertical axis (see figure 2).

3. Test on laboratory spectra

To test the pipeline, we generate synthetic data cubes with CRISM characteristics from laboratory library spectra. We use laboratory spectra from RELAB library.

We then artificially introduce noise to our synthetic data cube to reach the same signal to noise ratio as CRISM data. We applied our personal pipeline and compare the final product to noised spectrum and the original spectrum. The figure 1 presents the case of a laboratory spectrum of serpentine artificially noised. The thin absorption of serpentine spectrum centered at 2.32 µm is conserved at the same position but is a slightly enlarged. The absorptions smaller than the noise level are lost. The

others are reduced by the smoothing steps and enlarged by the whole process but we still easily identify them after all. Moreover, we test and there is no consequence on the use of spectral criteria for detection of minerals. We consider that our personal noise removal pipeline successfully passed the test.

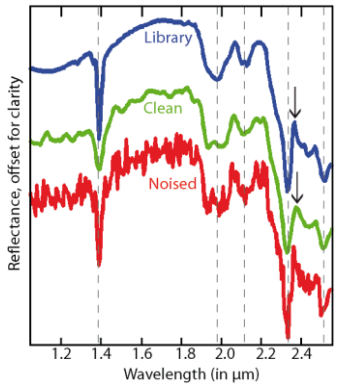

Figure 1: Test of our pipeline on a library spectra from RELAB (SERPENTINE C2CR01). The dotted lines show the absorption features important to conserve (1.39; 1.93; 2.12; 2.32; 2.51µm). The black arrow indicates the maximum of reflectance at 2.36µm.

To test the efficiency of the combinations of absorptions plot, we run the tool on synthetic data cubes. An example is given in figure 2. The synthetic data cube mixes alteration minerals with mafic minerals. The mineralogical diversity of the cube is clearly visible on the plot and the tool successfully highlights the 100 pixels of serpentine, chlorite and dolomite. Several other synthetic data cubes have been tested changing the ratio of mafic mineral and alteration phases. Each time, the tool successfully passed the test.

4. Conclusion

Our new noise removal pipeline and our tool of analysis can be used for systematic study of the CRISM data to improve mineral detection and determination. These methods already allow us to detect miscellaneous phyllosilicates and carbonates over thirty CRISM data cube [6]. Perspectives of development of the analysis tool include the enlargement of the spectral domain down to 1.7 µm and the adaptation to others hyperspectral data.

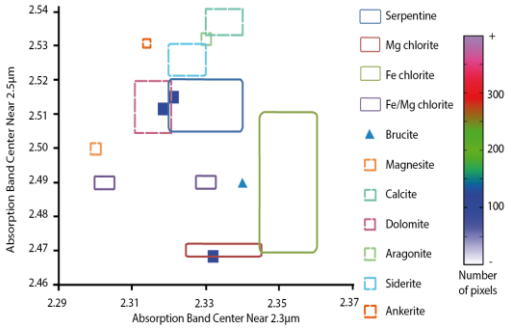

Figure 2: Test of our analysis tool on an artificial hyperspectral cube compose of 100 pixels with serpentine (SERPENTINE C2CR01, RELAB), 100 pixels of chlorite (CHLORITE , RELAB), 100 pixels of dolomite (DOLOMITE, JHU), 2500 pixels of fayalite (FAYALITE C1PO58, RELAB), 2500 pixels of forsterite (FORSTERITE C1PO50, RELAB), 2500 pixels of enstatite (ENSTATITE C2PE30, RELAB), 2500 pixels of diopside (DIOPSIDE C1PP09, RELAB). The theorist positions of center of absorptions are from [8], [10], [11] and [12]. The colored scale represents the number of pixels.

References

[1] Murchie, S., et al., 2007, J. Geophys. Res., 112. [2] Langevin et al., 2005b, Science , Vol. 307. [3] McGuire et al., 2008 Transactions on geoscience and remote sensing, Vol. 46 Issue 12 p. 4020-4040. [4] Parente, M. , 2008, LPSC 39. [5] Ehlmann B. L., et al., 2009, J. Geophys. Res., 114. [6]Bultel et al., 2013, EPSC2013, (this conference). [7] Carter et al., 2013, J. Geophys. Res. Planets, 118. [8] Gaffey, 1987 J. Geophys. Res., Vol. 92, No. B2, 1429-1440. [9] Bishop et al., 2013, J. Geophys. Res. Planets, Vol. 118, 487–513. [10] Gaffey, 1986 American Mineralogist, Vol. 71, 151-162. [11] Salisbury, et al., 1991b, Johns Hopkins University Press, 294 pp. [12] Bishop et al., 2008 Clay Minerals, 43, 35–54.

Acknowledgements

The research leading to these results has received funding from the European Research Council under the European Union's Seventh Framework Program (FP7/2007-2013)/ERC Grant agreement n° 280168.